PHYSICS

THE PHYSICS MAJOR AT A GLANCE: Physics involves the study of the small and very small (atoms, molecules, nuclei and elementary particles), the large and very large (the Earth, Moon, solar system, stars, galaxies, and the universe), the strange (black holes, anti-matter and superconductivity), the common (swings on playgrounds, springs and wheels), the relevant (space systems sensors and the motions of aircraft and satellites), and just about anything else! In other words, the scope of physics is limited only by the imagination of the physicist. Because the scope of physics is so broad, a physicist must be a generalist who can see the underlying connections between diverse topics. As a result, the Physics Major concentrates on the basic physical and mathematical principles that help us understand the world. This is also why the Physics Major is so flexible; your vision can help you design a Physics sequence that fits your role as an Air Force officer. The Physics curriculum blends traditional academic instruction, practical laboratory work and independent research projects to develop your ability to think creatively and analytically.

The Physics Major has a reputation for being challenging, but its rewards are great. It will prepare you for a successful career in the increasingly technical Air Force, and reward you with satisfaction in mastering a rigorous, demanding discipline. Physics is never obsolete; it forms the foundation upon which new technologies rest. Whether operational or scientific in nature, the technical innovations in today's Air Force have physics as their fundamental element.

COURSE REQUIREMENTS: 147 Semester Hours

A. *85 Semester hours of Dean's academic core courses including the following core alternates:*

Core Substitute		**Substitutes for**
Physics 421	Thermal and Statistical Physics	Systems Option
El Engr 231	Electrical Circuits and Systems I	El Engr 215
Math 356	Probability and Statistics for Engineers and Scientists	Math 300

B. *6 Semester hours of Commandant's academic core courses.*

C. *5 Semester hours of Director of Athletics core courses.*

D. 3 *Semester hours of Academy Option courses.*

E. *12 Semester hours in Applied Mathematics as follows*:

1. Math 243 Calculus III
2. Math 245 Differential Equations and Matrices
3. Math 346 Engineering Mathematics

4. Math 469 Partial Differential Equations

F. *24 Semester hours in Physics:*

1. Physics 264 Modern Physics (Fall or Spring)
2. Physics 341 Laboratory Techniques (Fall or Spring)
3. Physics 355 Classical Mechanics (Fall)
4. Physics 356 Computational Physics (Spring)
5. Physics 361 Electromagnetic Theory I (Fall)
6. Physics 362 Electromagnetic Theory II (Spring)
7. Physics 442* Advanced Laboratory (Fall or Spring)
   or Physics 480 Astronomical Techniques (Fall or Spring)
8. Physics 465 Quantum Mechanics (Fall)
9. Physics 405 First-Class Seminar (Fall)

* Cadets who elect the Astronomy and Space Physics Option usually take Physics 480. Others take Physics 442.

G. *12 Semester hours in one of the following options*. Most of our Physics majors align themselves with one of the following options:

Astronomy and Space Physics Option:

1. Physics 371 Astronomy (Fall)
2. Physics 451 Plasma (Fall)
3. Physics 453 Solar Planetary Interactions (Spring) or
   or Physics 486 Astrophysics (Spring)
4. Physics Option See Supplemental Information

Laser Physics Option:

1. Physics 391 Introduction to Optics and Lasers (Fall)
2. Physics 482 Laser Physics and Modern Optics (Spring)
3. Physics 393 Solid State Physics (Fall) or
   or Physics 468 Atomic and Nuclear Physics (Spring)
4. Physics Option See Supplemental Information

You may also propose a sequence of your own by selecting at least four courses (12 credit hours) from the Department of Physics or other Academy academic departments. It is *your* responsibility to identify a coherent four-course sequence. Normally, at least two of the selected courses must be 300-level or higher and one must be a 400-level course. **All sequences** must be approved by the Department of Physics AIC and the department's Director of Advanced Programs. Some popular sequences, which have been completed in the past, are shown below.

Aircraft Propulsion Design: Aero Engr 241/Aero Engr 341/Aero Engr 361/Aero Engr 466
Atmospheric Physics: Meteor 320/Meteor 330/Meteor 430/Meteor 431
Digital Computer Design: El Engr 281/El Engr 382/El Engr 383/El Engr 484

*Mathematical Physics**: Math 377/Math 359 or Math 360/Math 451/Math 470
Medical Physics (pre-med): Chem 233/Chem 234/Chem 243/Biology 431
Space Vehicle Design: Astro Engr 331/Astro Engr 351/Astro Engr 436/Astro Engr 437
Space Experiment Design and Analysis: Astro Engr 436/Astro Engr 437/Physics 451/Physics 453

*Students in this sequence should take Math 378 in lieu of Math 356. Math 378 satisfies the Math Core Statistics requirement.

Supplemental Information:
The Physics Option may be any 300-level or higher physics course, including:

Physics 310	Principles of Nuclear Engineering (Spring)
Physics 315	Combat Aviation Physics (Spring)
Physics 370	Upper Atmospheric and Geo-Space Physics (Spring)
Physics 495	Special Topics (Fall/Spring)
Physics 499	Independent Study (Fall/Spring)

You may also take the following courses as part of the Physics Option:

Math 470	Mathematical Physics (Spring)
Meteor 320	Introduction to Atmospheric Science (Fall)
Meteor 330	Atmospheric Physics (Spring)
Meteor 430	Atmospheric Dynamics I (Fall)
Meteor 431	Atmospheric Dynamics II (Spring)

SUGGESTED COURSE SEQUENCE:

Physics Major

	4º	hrs	per	3º	hrs	per	2º	hrs	per	1º	hrs	per
	Chem 141	3	2	Math 243	3	1	Physics 355	3	1	Physics 442/480	3	2
	History 101	3	1	**Civ Engr 210**	3	1	Physics 361	3	1	Physics 465	3	1
Fall	**English 111**	3	1	**Beh Sci 110**	3	1	Physics Conc 1	3	1	Physics Conc 2	3	1
	Math 141	3	1	**English 211**	3	1	Math 346	3	1	Physics 405	0	1
	Engr 100	3	1	**Physics 215**	3	2	**Econ 200**	2	2	Math 469	3	1
				Soc Sci 112	3	1	**Mgt 200**	2		**Beh Sci 310**	3	1
	Phy Ed	0.5	2	*Phy Ed*	1	2	**Pol Sci 311**	3	1	**Physics 421 ***	3	1
							Phy Ed	1	2	*Phy Ed*	1	2
		15.5	8		19	9		20	9		19	10
	Physics 110	3	2	Physics 264	3	1	Physics 341	3	2	Physics Conc 3	3	1
	Chem 142	3	2	Math 245	3	1	Physics 356	3	1	Physics Conc 4	3	1
Spring	**Math 142**	3	1	**El Engr 231**	3	1	Physics 362	3	1	***Academy Option***	3	1
	Comp Sci 110	3	1	**Biology 215**	3	2	**Law 220**	3	1	**English 411**	3	1
	Engr Mech 120	3	1	**Math 356 ***	3	1	**Philos 310**	3	1	**Astro Engr 410**	3	1
	MSS 100	3	1	**History 202**	3	1	**Aero Engr 315**	3	1	**MSS 400**	3	1
	Phy Ed	0.5	2	*Phy Ed*	0.5	2	*Phy Ed*	0.5	2			
		18.5	10		18.5	9		18.5	9		18	6

Course unit summary:
Core (31*)
Major (16**)
Academy Option (1)
Phy Ed (10)

Semester Hour Summary		
Core =	**91.0**	Sem Hours
Major =	48.0	"
Academy Option =	3.0	"
Phy Ed =	5.0	"
Total =	**147.0**	"

PHYSICS (Physics)
Offered by the Department of Physics (DFP)

Physics 110. General Physics I. 3(2)*. Introductory calculus-based physics course with emphasis on contemporary applications (first semester). Topics include Newtonian mechanics; conservation of energy, momentum and angular momentum; oscillations and waves; and special relativity. Emphasizes the use of vectors and calculus in problem solving. Course includes in-class laboratories and computer applications to highlight key concepts. Final exam. Prereq: Completed or enrolled in Math 142. Sem hrs: 3 fall or spring.

Physics 215. General Physics II. 3(2)*. Introductory calculus-based physics course with emphasis on contemporary applications (second semester). Topics include electrostatics, simple DC circuits, magnetic fields, electromagnetic induction, electromagnetic waves, physical optics, and selected topics in modern physics. Uses vectors and calculus in problem solving. Course includes in-class laboratories and computer applications to highlight key concepts. Course must be taken in the semester immediately following the successful completion of Physics 110. Final exam. Prereq: Physics 110 and Math 142. Sem hrs: 3 fall or spring.

Physics 264. Modern Physics. 3 (1). Introduction to the special theory of relativity and a historically-based development of quantum theory. Investigation of Bohr model of the atom. Introduction to quantum mechanics and its application to problems involving simple forms of potential energy. Possible application topics include atomic and molecular physics, solid-state physics, nuclear reactions and decay, and elementary particles. Final Exam. Prereq: Completed Physics 215 or department permission; completed or enrolled in Math 243. Sem hrs: 3 fall or spring.

Physics 310. Principles of Nuclear Engineering. 3(1). A survey course in the aerospace uses of nuclear energy. This course introduces the student to the sources and uses of nuclear energy from radioactive decay, fission, and fusion. It covers such topics as nuclear space propulsion and power; ground-based nuclear power; the production, effects, and detection of nuclear weapons; the protection of man and aerospace assets from nuclear radiation; and the safe disposal of radioactive waste. Final exam. Prereq: Physics 215 or department permission. Sem hrs: 3 spring.

Physics 315: Combat Aviation Physics. 3(1). A broad-based study of the principles of physics as they directly apply to the realm of combat aviation. The course covers two topical areas: the physics of flight as a dynamic investigation of forces and energy applied to the combat maneuvering required to win air-to-air engagements; and the combat use of the electromagnetic spectrum, primarily as it applies to radar, IR seekers, and countermeasures. Final exam. Prereq: Physics 215. Sem hrs: 3 spring.

Physics 341. Laboratory Techniques. 3(2). An introductory laboratory course developing skills in experimental techniques and data analysis. Course includes

instruction in the use of various types of electronic instrumentation and devices to analyze and design electrical circuits. Experiments will investigate the laws and principles of modern physics taught in Physics 264. No final exam. Prereq: Physics 215, completed or enrolled in Physics 264, or department permission. Sem hrs: 3 fall or spring.

Physics 355. Classical Mechanics. 3(1). An examination of the underlying classical laws governing the general motion of bodies. The topics covered include vector calculus, Newtonian dynamics, Lagrangian and Hamiltonian dynamics, the law of gravity and central-force motion, two-particle collisions and scattering. Possible other topics include linear and coupled oscillations, noninertial reference frames, chaos, transformation properties of orthogonal coordinate systems and rigid-body motion. Extensive application of calculus, ordinary differential equations and linear algebra will be made in the solution of problems. Final exam. Prereq: Physics 215; completed or enrolled in Math 346 or department permission. Sem hrs: 3 fall.

Physics 356. Computational Physics. 3(1). An introduction to solving complex physical problems using numerical techniques. Subjects covered may include: kinematics, damped/driven oscillators, nonlinear dynamics, chaos, coupled oscillators, waves, thermal diffusion, and electromagnetic potentials. Methods presented include regression analysis, numerical differentiation, and solutions to ordinary and partial differential equations. Final Exam or Final Project. Prereq: Physics 355 and Math 346; or department permission. Sem hrs: 3 spring.

Physics 361. Electromagnetic Theory I. 3(1). Develops Maxwell's equations and basic principles of electromagnetism. Includes electrostatic fields in both vacuum and in dielectrics, the Laplace and Poisson equations, magnetic fields associated with constant and time varying currents, and magnetic materials. Final exam. Prereq: Physics 215 or department permission; completed or enrolled in Math 346. Sem hrs: 3 fall.

Physics 362. Electromagnetic Theory II. 3(1). Applications of Maxwell's Equations: plane waves, reflection, refraction, guided waves, electric and magnetic dipoles and quadruples, and antennas. The interaction between plane waves and plasmas is treated. Basics of relativistic electrodynamics are introduced. Final exam. Prereq: Physics 361. Sem hrs: 3 spring.

Physics 370. Upper Atmospheric and Geo-Space Physics. 3(1). A survey course on the composition and physics of the upper atmosphere and the near-earth environment. Topics include solar-terrestrial interactions; observations, phenomena and military operations in the near-earth environment; structure, dynamics and transport in the upper atmosphere; and energy transfer, remote-sensing, and military operations in the upper atmosphere. Final exam. Prereq:
Physics 215. Sem hrs: 3 spring.

Physics 371. Astronomy. 3(1). A calculus-based study of the fundamental concepts of astronomy. Emphasis is placed on understanding the basic physical concepts that explain

stellar structure, stellar evolution, galactic structure, the solar system and the origin of the universe. Includes up to three night classes at the Academy Observatory. Final exam. Prereq: Physics 215 or department permission. Sem hrs: 3 fall.

Physics 391. Introduction to Optics and Lasers. 3(1). A survey course in optics. Including: geometrical optics (lenses, mirrors, ray tracing, and optical instruments); physical optics (interference, diffraction, polarization, spectra, and scattering); introduction to lasers (laser operation, pumping, resonators, and optical cavities); and contemporary topics (Fourier optics, imaging, and holography). Final Exam. Prereq: Physics 215; completed or enrolled in Math 245; or department permission. Sem hrs: 3 fall.

Physics 393. Solid State Physics. 3(1). Introduction to the physics of the solid state nature of
matter. Crystal structure, crystal binding, lattice vibration, free electron theory and band theory. Basic introduction to quantum theory and quantum statistics of solids. Theories are used to explain metals, semi-conductors and insulators. Survey topics include magnetism, superconductivity, optical phenomena in solids, crystal imperfections and the physics of solid state devices. Final exam. Prereq: Physics 215; completed or enrolled in Math 245. Sem hrs: 3 fall.

Physics 405. First-Class Seminar. 0(1). A problem solving course reviewing major areas of undergraduate physics. No final exam. Pass/Fail. Prereq: Physics 356 or department permission. Sem hrs: 0 fall.

Physics 421. Thermal and Statistical Physics. 3(1). Classical thermodynamics with an emphasis on thermodynamic laws and applications to cycles. Kinetic theory, statistical thermodynamics, and quantum statistics. Applications of statistics to quantum systems. Final exam. Prereq: Math 356 or Math 300; completed or enrolled in Physics 465 or Chem 336; or department permission. Sem hrs: 3 fall.

Physics 442. Advanced Physics Lab. 3 (2). A series of selected experiments to develop the student's laboratory skills and reinforce basic physical concepts. Possible topics covered include atomic and molecular physics, gamma ray spectroscopy, laser physics, proton-induced elementary nuclear reactions, x-ray crystallography, optical interferometry and holography, and nonlinear optical processes. The experiments are performed by small groups of students working as teams. Emphasis on the ability to write and brief technical subjects to a technical audience. No final exam. Prereq: Physics 341 and Physics 264 or department permission. Sem hrs: 3 fall or spring.

Physics 451. Plasma Physics. 3(1). A comprehensive introduction to the plasma state of matter. Topics include single particle motion, adiabatic invariants, fluid description of a plasma, waves in plasmas, kinetic theory, diffusion and resistivity, and stability. Final exam. Prereq: Physics 362 or department permission; completed or enrolled in Math 346. Sem hrs: 3 fall.

Physics 453. Solar-Planetary Interactions. 3(1). Discussion of the basic physical principles controlling the sun's interaction with planetary atmospheres. Topics include the dynamics and structure of the solar atmosphere, origin of the solar wind and the interaction of the solar wind with space vehicles, Earth-based systems and the Earth's plasma environment. Quantitative descriptions of electric currents and fields, and auroral and atmospheric dynamics will be introduced. Final Exam. Prereq: Physics 451 or department permission. Sem hrs: 3 spring.

Physics 465. Quantum Mechanics. 3(1). Basic principles of quantum mechanics. Postulates. Dirac notation. Schrodinger's equation. Operators, eigenfunctions and eigenvalues. Potential barriers and wells. Simple harmonic oscillator. Orbital and spin angular momentum. Addition of total angular momentum. Hydrogen atom. Elementary radiation theory. Time-independent perturbation theory. Two-level systems. Stark effect. Fine structure. Final exam. Prereq: Physics 264 and Math 346, or department permission. Sem hrs: 3 fall.

Physics 468. Atomic and Nuclear Physics 3(1). Treatment of the fundamental physical concepts governing all of microscopic physics which includes elementary particle, nuclear, atomic and molecular physics. The topics covered include the standard model of elementary particles and interactions symmetries and conservation laws, gauge theories, properties of the nucleus, nuclear models, nuclear interactions and decays, scattering theory, atomic systems, atomic and molecular spectroscopy techniques. Final exam. Prereq: Physics 465 or department permission. Sem hrs: 3 spring.

Physics 480. Astronomical Techniques. 3(2). Introduction to optical astronomy using the USAFA 24" and 16" telescopes during 9 scheduled night laboratories. Emphasis on equipment operating principles, scientific method, data reduction and reporting results. Includes astrophotography, photoelectric photometry, charge coupled devices and spectroscopy. Final exam or final project. Prereq: Physics 371, or department permission. This course has limited enrollment; all registrations must have department approval. Sem hrs: 3 fall or spring.

Physics 482. Laser Physics and Modern Optics. 3(1). A detailed study of the operation of the laser: types of lasers, lasing media, pumping mechanisms, resonators and cavities, laser modes and Gaussian properties. Covers modern optics: introductory electro-optics, nonlinear optics, statistical optics and quantum mechanical analogs of optical systems. Final exam. Prereq: Physics 362 or El Engr 444; or department permission. Sem hrs: 3 spring.

Physics 486. Astrophysics. 3(1). Application of physics to astrophysical problems and topics of current interest in astrophysics. Typical topics include stellar structure and evolution, supernovae, white dwarfs, neutron stars, black holes, galactic structure, active galaxies, quasars, cosmology and general relativity. The choice of topics depends on instructor and student preferences. Final exam. Prereq: Physics 264 and Physics 362, or department permission. Sem hrs: 3 spring.

Physics 495. Special Topics. 3(1). Selected topics in physics. Final exam or final report. Prereq: Department permission. Sem hrs: 3. Offering time determined by department.

Physics 499. Independent Study. 3(0). Individual research under the direction of a faculty member. Final report. Prereq: Department permission. Sem hrs: 3 fall or spring.

Physics 499A. Independent Study. 2(0). Individual research under the direction of a faculty member. Final report. Prereq: Department permission. Sem hrs: 2 fall or spring.

Physics 499B. Independent Study. 1.5(0). Individual research under the direction of a faculty member. Final report. Prereq: Department permission. Sem hrs: 1.5 fall or spring.